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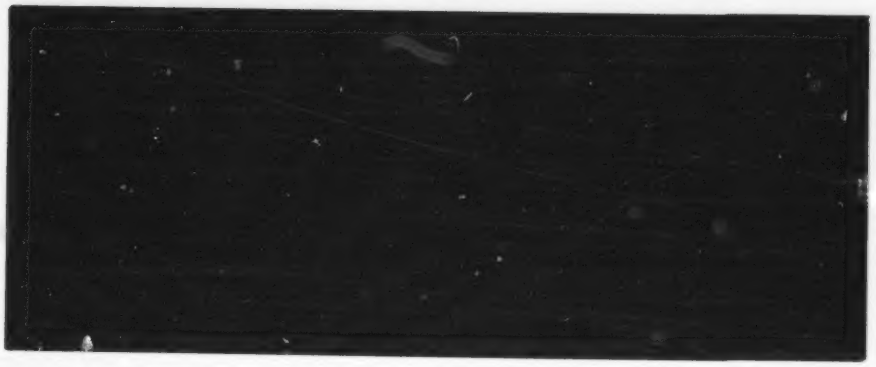

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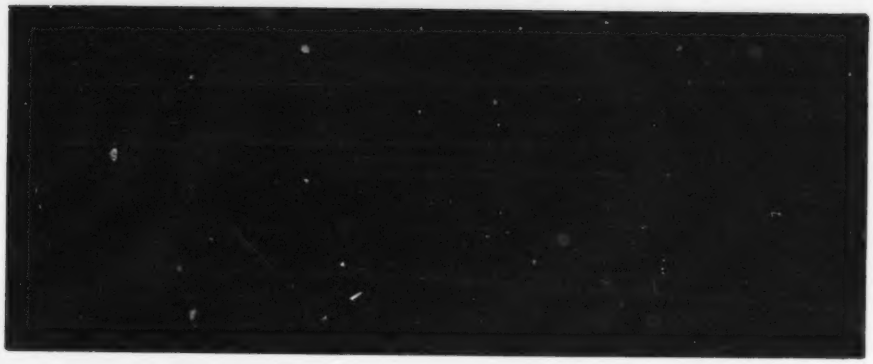

91-01788/

Final Report

2.4-15

Herd Health of Game Farm Animals

Conducted by Dr. Haigh

Saskatchewan Game Farmers Association

Funded by the Agriculture Development Fund

Herd Health of Game Farm Animals ERDA project # 2.4-15

ABSTRACT

This report covers surveys of diseases of farmed elk and bison in western Canada, as well as information on vaccination of elk against clostridial diseases and rabies.

Many of the diseases encountered on game farms may be prevented by good management, quality nutrition, well designed yards and safe handling facilities. Neither gut nor lung worms appear to be a problem for farmed elk in Saskatchewan under normal conditions, but bison should be closely monitored and treated when necessary.

Prophylactic vaccination of deer, elk and bison against clostridial diseases is recommended on at least a yearly basis.

TECHNICAL REPORT

The original scope of the study called for a three phase research study to be made of diseases of game farm animals that would comprise the objects of a fecal survey of several farms, gastrointestinal examination of post-mortem specimens submitted to the WCVM and a study of the effects and efficacy of rabies and clostridial vaccines on game farm species. The study was carried out by Dr. Judit Smits DVM as a part of the requirements for and M.V.Sc degree.

We were able to substantially expand the scope of the study due to several different circumstances.

The extra items that we were able to achieve are outlined below.

First, we were able to obtain extensive retrospective data from laboratories across western Canada and the north-western United Sates. These data provided us with a ten year look at causes of death among farmed and research raised elk. Dr. Smits is currently preparing the data for scientific publication, but a copy of the report generated is enclosed (appendix 1). This report has been used as a class requirement in partial fulfillment of an MVSc degree by Dr. Smits.

Second, by the application of additional funding from Alberta and the use of some of the ERDA funds were able to take advantage of an opportunity to send Dr. Smits to Australia to work under the supervision of Dr. Tony English at the University of Sydney. The major benefit gleaned from her trip was an increased knowledge of the diseases and management of fallow deer. Two reports were generated following this trip, both of which have already been sent to Saskatchewan Agriculture officials in Regina. Copies of these are also enclosed (appendices 2 & 3). Dr. Smits also visited New Zealand and some of the information that she gained there has also been incorporated into the above reports.

Third, the availability of a small research herd of farmed deer at Marimba farm Inc. enabled us to study the effects of immobilizing drugs and their antagonists. Of particular interest was the finding that Yohimbine, a drug formerly thought to be usable only by intravenous injection, could satisfactorily be used intramuscularly. A scientific paper has already been published on the results of this work. A copy is enclosed (appendix 4).

NON-TECHNICAL REPORT

a. Elk fecal sample survey 1988

Unless fecal sampling has shown that a problem exists there is little point in administering anthelmintics to elk.

b. Rabies vaccination trial

Vaccination of elk with Imrab™ rabies vaccine produces a measurable response in most animals. No conclusions can be drawn on whether the antibody responses measured would protect an elk in the face of a challenge with virulent rabies virus.

c. Clostridial vaccination of deer

Vaccination of elk with a clostridial vaccine, at least yearly, and perhaps as often as every six months, is advised. Furthermore there is some evidence to suggest that vaccination of pregnant females causes a measurable antibody response in offspring.

d. Elk diseases - adults & yearlings

Good management, yard and pen design is absolutely central to successful elk farming. Good nutrition plays a central role in the prevention of diseases and economic loss on game farms. A number of infectious diseases were diagnosed (see report for details) but the most important cause of death and disease is trauma.

e. Bison diseases

The most important cause of disease and economic loss on bison farms is parasite infestation. The most important intestinal parasites recorded were *Ostertagia* (brown stomach worm), *Hemonchus* (barber pole worm) and *Trichostrongylus*. Lungworm (*Dictyocaulus spp*) has also caused severe losses in ranched bison.

f. Deer diseases

Improper nutrition and trauma are the two most important causes of disease and economic loss in deer. In fallow deer this is reflected throughout the year. Undernourished does produce less young than optimum. The progeny are of lower weight than desired. The progeny do not thrive, and a reduce weaning percentage is seen. These same progeny do not reach desired carcass weights at optimum time and female yearlings are under weight and therefore have a reduced chance of conception at their first breeding season.

Similar detailed work on the production of white-tailed deer and mule deer are lacking. There is no doubt that undernutrition and trauma are important in both of these species. They also appear to be more susceptible than elk to a variety of infectious diseases. These include intestinal parasites, including Coccidia, and pneumonia.

g. Diseases of neonates - Elk, Deer & Bison

All neonatal ungulates share common diseases. The important ones are related, in the first 2 or 3 days of life, to exposure, mismothering or undersize. Subsequently infectious diarrhea is the most important problem.

PUBLICATIONS

Publications resulting from the project are listed. In addition Dr. Smits carried out a number of speaking engagements related to the project. These are listed separately.

EXPENDITURES

The office of research accounts has provided a separate itemized list of accounts.

EQUIPMENT

No equipment was purchased.

Elk Fecal Parasite Survey 1988

Fecal samples were collected monthly on five Saskatchewan game farms from May through September 1988. Samples were taken from adults, yearlings and calves and examined for various gastrointestinal and lung parasites. The results of this 5 month survey have been summarized below.

Adults - total 95 samples
- 13 positive for gastrointestinal nematodes = 14%
- 2 positive for eimeria spp. = 2%

Yearlings - total 68 samples
- 16 positive for gastrointestinal nematodes = 24%
- 11 positive for eimeria spp. = 16%

Calves - total 41 samples
- 6 positive for gastrointestinal nematodes = 15%
- 7 positive for eimeria spp = 17%

All samples were negative for protostrongylid (lungworm) worms.

All the positive results were at the lowest level that is recorded i.e. +1 on a scale of 1 to 4. There was one exception to this finding. One yearling heifer had a transient level of +4 eimeria which decreased to undetectable levels on a subsequent test. These very low levels indicate either that elk are very resistant to common gut and lung parasites which are pathogenic to other domestic ruminants, or that there were poor conditions for parasite survival on all the elk farms monitored. The most likely explanation is a combination of these two.

Conclusions: The semi-arid conditions of many parts of Saskatchewan and the inherent resistance of elk to common parasites helped to minimize the problems caused by endoparasites. However, in different climatic conditions this situation could change. It is recommended to monitor all age groups for fecal parasites on a seasonal basis with special attention given to susceptible groups such as newly weaned young and post-rut males. Infected groups should be treated and retested. Management of pastures can minimize the exposure of the most vulnerable groups.

Rabies Vaccination Trial

A rabies vaccination trial was carried out in cooperation with Dr. Ken Loewen at the Animal Diseases Research Institute (ADRI) in Lethbridge, Alberta. Elk were vaccinated with "Imrab", a commercially available rabies vaccine. Pre-vaccination and post-vaccination serum samples were collected from 16 elk. The serum was sent to ADRI where a new assay "rabies REFIT" method was used to analyse the antibody levels before and after exposure to rabies antigen. This was the first effort with this assay and therefore there were no internal controls or reference sera.

Post-vaccinal titres of < or = 4 are interpreted as negative. There were no negative post-vaccination titres in this trial.

pre-vaccination sample titres	16	< 1/4
	1	1/6
	1	1/8
post-vaccination sample titres	2	1/8
	1	1/12
	2	1/16
	1	1/24
	2	1/32
	2	1/48
	2	1/64
	1	1/86
	2	1/128

None of the elk maintained negative titres after being vaccinated. It is not known whether these levels of antibody are protective in cases of exposure to live rabies virus.

Clostridial Vaccination of Deer

The pharmaceutical companies which manufacture vaccines against clostridial diseases, were unable to support us with this research. Instead, they did make available to us the results of two trials that had been recently carried out in Great Britain. This information has been interpreted for the report and can be usefully incorporated into the management of game animals until more detailed studies are carried out.

There were two different vaccination trials with clostridial vaccine in deer. One trial compared the serum antibody levels achieved using two different clostridial vaccines; 'Heptavacc' and 'Covexin-8'. Both vaccines contain Cl. perfringens types C,D, Cl. septicum, Cl. chauveoi, Cl. tetani and Cl. novvi type B combined bacterin and toxoid. 'Heptavacc' alone contains Cl. perfringens type B, while 'Covexin' alone contains Cl. hemolyticum.

This trial used three groups of animals; one treated with 'Heptavacc', one treated with 'Covexin' and one control group. In the 5 clostridial antigens that were tested for, there was a consistently much greater response to 'Heptavacc' than 'Covexin'. This would imply that if antibodies confer protection, then 'Heptavacc' would offer the greater defence against clostridial diseases.

The second trial used 20 hinds and their calves to test for the serological response to vaccination with 'Heptavacc'. The hinds were vaccinated twice before calving. The antibody titres had increased 10 to 50 times after the booster (2nd) vaccination compared to the first vaccination. The calves of vaccinated hinds had significantly higher antibody levels than the calves from non-vaccinated hinds. This indicated successful maternal antibody transfer to the calves.

These findings do not prove the protectiveness of vaccination but they do support the presently accepted recommendation of routine vaccination of farmed deer on an annual basis.

Elk Diseases - Adults and Yearlings

These disease problems have been summarized from 10 years of necropsy reports from veterinary pathology laboratories in western Canada and the northwestern United States. This particular region was chosen in an attempt to get a population representative of the elk ecosystems found in Saskatchewan. There were 114 necropsy reports for adult elk.

Major diseases:

1. Trauma (40% of the males necropsied)
   (26% of the females necropsied)

2. Emaciation (often concurrent diseases seen)

3. Pneumonia (*Pasteurella multocida*)
   (*Actinomyces pyogenes*)

4. Post-capture myopathy (immobilization complications)

5. Nephritis (more common in females)

Other diseases: footrot (not in arid regions)
peritonitis
arthritis
dental attrition

Bison Diseases

The information here comes from sources in western Canada. A total of 99 necropsy reports were studied.

Major diseases:

1. Parasites - gastrointestinal nematodes - ostertagia
   - hemonchus
   - trichostrongylus

   - lungworm - dictyocaulus sp.

2. Emaciation/malnutrition

3. Pneumonia - P. multocida, P. hemolyticum

4. BVD - diarrhoea, oral and GIT lesions

5. Peritonitis - hardware disease

Other diseases: ketosis in pregnant females
grain overload
trauma
footrot
mycotic abortions
degenerative arthritis

Deer Diseases

The deer species included fallow deer, white-tailed deer and mule deer raised in captive environments.

Major diseases:

1. Emaciation/malnutrition
2. Pneumonia
3. Trauma
4. CNS problems - brain abscesses - skull trauma
   - foreign bodies
   - bacterial or viral infections
   - nutritional problems (polioencephalomalacia)
5. Gastrointestinal problems - grain overload
   - abomasal or enteric ulcers
   - parasites
   - oral necrobacillosis
   - mycobacterial enteritis

Diseases of Neonates - Elk, Deer and Bison

This very young of most animal species share vulnerabilities to certain types of diseases. The game farmed ungulates are no exception; they suffer similar problems in the same order of importance.

1. Dehydration - non-viable calf/fawn (too small)
   - exposure (heat or cold)
   - mismothering (first time mothers usually)

2. Diarrhoea - coliform diarrhoea
   - occasionally salmonella or viral diarrhoea

3. Septicemia - hand-reared young especially

4. Predation - predation especially with smaller species

5. Pneumonia - aspiration (force-feeding)

List of Publications - M.V.Sc. 1987-1989
Judit E.G. Smits, D.V.M.

1. Intramuscular Yohimbine Hydrochloride Reversal of Xylazine Sedation in White-tailed Deer (Odocoileus virginianus) and Mule deer (O. hemionus). Journal of Zoo and Wildlife Medicine 1989, 20: 170-172.

2. Polioencephalomalacia in a Captive Fallow Deer (Dama dama,), manuscript in review, September 1989.

3. Production Parameters in Deer Farming - Alberta Agricultural Research Institute - Research Coordination Program report. (AARI -Research Coordination Program).

4. Reproductive Performance in Fallow Deer (Dama dama) AARI - Research Coordination Program report.

5. Malignant Catarrhal Fever - Report to the Saskatchewan Technical Game Farming Advisory Committee.

6. Elk Diseases: A Review of Diseases of Captive and Semi-Captive Elk in Western Canada and the Northwestern U.S.A. Manuscript in review, September 1989.

7. Elk Disease Survey in Western Canada and the Northwestern United States, manuscript in review, September 1989.

Papers Presented

1. Game Farm Management; Regional and Foreign Animal Disease Seminar, Agriculture Canada, Feb. 1988.

2. The Quality of Game Meat; Workshop on the quality of game meat, Western College of Veterinary Medicine, Feb. 1988.

3. Care and Handling of Injured Birds; Regional Conservation Officer Seminar, Sask. Parks, Recreation and Culture, Mar. 1988.

4. Disease and Animal Welfare Concerns in Big Game Farming; Board of Directors of the Sask. Society for Prevention of Cruelty to Animals, Oct. 1988.

5. Game Farming in Canada; New South Wales Deer Breeders Conference, Camden, N.S.W. Australia, Dec. 1988.

6. Deer Farming Down Under; WCVM department seminar, April 1989.

7. Saskatchewan Disease Report; Joint Canadian/Saskatchewan Game Farmers Association Annual Meeting, Lloydminster, Mar. 1989.

8. Game Farming Set Up in Saskatchewan; Rural Minicipality of Medstead Agricultural Committee, Apr. 1989.

9. Deer Farming in Australia; College Seminar, Western College of Veterinary Medicine, Sk. Apr. 1989.

10. Malignant Catarrhal Fever; Game Animal Diseases Seminar, Sask. Technical Game Farming Advisory Committee, May 1989.

11. Disease Survey of Western Canadian Game Farms; Veterinarians in The Game Farm Industry, W.C.V.M. June Conference, Saskatoon, Sask. June 1989.

APPENDIX 1

Elk Disease Survey in Western Canada and Northwestern United States

Judit E.G.Smits

Dept. of Herd Medicine and Theriogenology

Western College of Veterinary Medicine

Introduction

There is a strong interest in many parts of the world in raising traditional game animals for meat production. The Canadian game farming industry, yet in its infancy, is developing and expanding very rapidly. Elk (Cervus elaphus canadensis), is the most popular cervid species for farming in western Canada, in provinces which allow the raising of native species on game farms. Presently, there are approximately 4,500 elk on 240 licenced game farms in Saskatchewan and Alberta alone. This number continues to grow as more people become involved in agricultural diversification efforts.

Because of the interest in and financial commitment to elk husbandry, there is a growing demand for veterinary services, herd health programs and preventative medicine schemes. There is a paucity of information about the types and prevalence of

diseases which affect this species. The intent of this study was to find out the major disease problems that have caused death in elk being raised in captive or semi-captive environments in the northern part of the western Great Plains and Rocky Mountain regions of Canada and United States.

Materials and Methods

A retrospective study of elk mortality was carried out. It was based upon necropsy reports from several provincial, state and veterinary college pathology laboratories. The particular labs were chosen in an attempt to get a population representative of the ecosystems (elk environments) found in Saskatchewan and Alberta. It was necessary to search through approximately ten years of data from most of the labs involved in order to get a meaningful number of cases. Not all labs had ten years of accessable data.

The necropsy records came from the Western College of Veterinary Medicine (WCVM) University of Saskatchewan, the veterinary diagnostic labs at South Dakota State University (SD) and North Dakota State University (ND), the Alberta Agriculture Pathology Labs in Edmonton and Airdrie, Alberta, the Saskatchewan

Agriculture Pathology Lab in Regina, Saskatchewan and the Wyoming Game and Fish Department in Laramie, Wyoming.

The cases were chosen based upon several criteria. Any case chosen had to come from a captive population, (zoo, game farm, research facility) or a semi-captive management system (game park or refuge). Cases used were only from animals which died on these premises and did not include abnormal tissues submitted from hunter killed animals.

The five age group designations were fetus, neonate (under three weeks of age), calf (over three weeks but under one year of age), mature (any animal at least one year of age) and unknown. The data was sorted into categories which included 22 specific diseases, plus 'other' and 'no diagnosis'.

Results

There were 231 necropsy case reports represented in this study. Each age group showed a predilection for certain diseases. Diseases which were seen in at least five animals were included in the summary in Table 1. One exception was in the smallest group (calf) where four cases in each of three diseases

represented a fairly high percentage of the total number of cases for the group.

Fetal Group

All but two of the fetal necropsies were done through the Wyoming Game and Fish lab, and all the confirmed brucellosis cases came from this lab. There was one aborted fetus from which a heavy growth of Ps. aeruginosa was cultured.

Neonatal Group

In the neonatal group, dehydration was commonly diagnosed if the animal was under two to three days of age, (since the brown fat reserves with which they are born, should have sustained them for that length of time, given adequate hydration). After this period, the most common diagnosis was emaciation even though dehydration may have been a contributing factor.

An etiologic agent was identified in 34 % of the 44 neonate necropsies. Among those with enteritis, five were positive for coronavirus and two had coliform enteritis and diarrhoea. E. coli was also isolated from six septicemic neonates. Meningitis was a common concurrent diagnosis with coliform septicemia. Other organisms cultured from septic neonates included Klebsiella

pneumonia, Ps. aeruginosa and Proteus sp. One case of pneumonia was confirmed as a mycotic infection, while another, with no agent cultured from the lungs, was associated with coronaviral enteritis. One hand reared neonate developed a perforating colonic ulcer.

Calf Group

Among the calves which died with emaciation, one had relatively high numbers of trichuris and coccidia in the gastrointestinal tract, while another had Pasteurella pneumonia. The rest showed no predisposing condition which might have caused the emaciation. Infectious agents demonstrated in the calves with enteritis were rotavirus, E. coli and Clostridium perfringens. The septicemic calves had predisposing conditions which would have increased their susceptibility to disease; two had omphalophlebitis (one of these had a systemic Actinomyces pyogenes infection and bronchopneumonia), two were being bottle raised and one was the smaller of twins. In every case with pneumonia there were other pathological processes going on. Besides those already mentioned (omphalophlebitis, emciation and septicemia), there was one calf with traumatic

reticuloperitonitis. In total, 44 % of the calves necropsied had an infectious agent identified.

Adult Group

In many cases the sex of the animals was not known. Therefore, only when there were clear differences among mature animals of known sex, were the data broken down by gender.

The most frequently diagnosed problem in the mature elk population was trauma. At 26 % it was considerably higher than the overall population rate of 18 %. Trauma was the main diagnosis in 40 % of the mature males necropsied, compared to 26 % of mature females.

Approximately the same percentage of adult males and females were diagnosed to be emaciated (19 and 18 % respectively). Many of these cases had other pathological conditions as well. Seven had pneumonia, five had footrot, five were traumatized, while others suffered from concurrent (in order of frequency) arthritis, nephritis, peritonitis, myocarditis, enteritis, capture myopathy, dental attrition or gastrointestinal parasitism. In just three cases was emaciation the sole diagnosis.

Fourty-five percent of the pneumonia cases had etiological diagnoses. A. pyogenes and P. multocida were the most frequently isolated agents. Mycoses were seen as both primary and secondary infections. There was one E. coli with Streptococcus sp. plus one Mycobacterium bovis among the pneumonia cases seen. Animals with pneumonia tended to have more than one problem as well. Besides emaciation which has already been mentioned, footrot, trauma and lungworm were also seen.

Nephritis was seen much more often in the females (73%) than in males (9%). E. coli and Pseudomonas with Enterobacter were isolated from the two cases which had positive cultures.

Deaths due to capture myopathy were reported most frequently from captive environments (92%). Suspected anaesthetic overdose or post-immobilization complications were associated with 67 % of the cases, while the rest were related to transport or misadventure.

The animals with footrot came from all three habitats, farm, research facility and park, with almost the same frequency. Interestingly, none of the footrot cases came from Saskatchewan, North Dakota or South Dakota.

Peritonitis was seen in conjunction with a variety of conditions. Two were secondary to gastrointestinal tract impaction, one was a mycotic induced intestinal obstruction, one had a post-calving intestinal accident (torsion) and one had hepatic abscessation and myocarditis. P. multocida, E. coli and Streptococcus sp. were agents isolated from peritonitis cases.

Arthritis was most often seen in farmed elk. It was seen as the sole pathological problem, as well as in conjunction with diagnoses of trauma and footrot.

In the Wyoming research herd, five elk deaths were confirmed to be due to spongiform encephalopathy or Chronic Wasting Disease, a disease with an unidentified etiology, suspected to be a 'slow virus'. This is the only situation to date in which it has been reported in elk although it has been described in captive mule deer (Odocoileus hemionus hemionus), black-tailed deer (O. hemionus columbianus) and a mule deer X white-tailed deer (O. virginianus) hybrid in wildlife facilities in Wyoming and Colorado (1).

Unknown Age Group

Among animals of unknown ages (which were therefore not

included in the table), there were several cases of peritonitis, arthritis and open diagnosis. There were two pneumonias, two cases with encephalitis and one each with pulmonary congestion and edema, blackleg, enteritis, fungal dermatitis and nephritis.

Discussion

The 'study population' in this survey consisted of cases seen in western university, state and provincial pathology laboratories over the past ten years. These laboratories were chosen because of somewhat similar climate and ecosystems to those found in Saskatchewan and Alberta. It was felt that there would be unavoidable problems with bias, due in part to the non-random sampling procedures. Cases submitted were most likely biased by geographical location and the proximity of dead animals to the respective labs. Cluster effects with infectious diseases may also be a complicating factor because of the relative confinement of the goups of animals that would have been found and submitted for diagnostic workups. Because of small numbers of elk being necropsied, it was necessary to use all the available information. By not using individual veterinary practitioner's necropsy reports, a wider information base was

forfeited for what is intended to be a more consistent one, laboratories being fairly similar in their diagnostic approach and the diagnostic tools available to them.

Brucellosis, the most important diagnosis of the fetus group, is a well documented entity in western Wyoming. A recognized focus of brucellosis has exsisted in the National Elk Refuge, Jackson, Wyoming since the 1930s (2,3). The disease appears to be limited to the elk population which frequents the winter feeding grounds established in the refuge. Serological surveys for brucellosis across the United States and including the rest of the state of Wyoming, have been carried out on thousands of ungulates including elk. They have shown that the prevalence of infection is less than 1 % (2,3,4). The most probable factor responsible for maintaning infection is the concentration of animals at the winter feeding grounds. Abortions occur during the winter, and infection is transmitted through licking or ingestion of contaminated materials such as fetal fluids, vaginal exudate and aborted feti. Venereal transmission has been shown to be unimportant (3).

Greater than 75 % of the feti were from the Game Research Unit of the Wyoming Game and Fish Department. Because of this,

the information on fetal deaths may be considerably biased. In order that feti are found before they are scavenged or otherwise disappear, there must be close and frequent surveillance of the the herd. Therefore this part of the survey may not provide a balanced overview of problems associated with pregnancy loss among elk.

Neonatal death diagnoses fell into the same categories as those seen among other domestic species. Dehydration was felt to be a more accurate description than emaciation for calves under three days of age, because fluid ingestion is much more critical than energy while they still have the fetal brown fat to metabolize. Both dehydration and emaciation likely share etiology. Mismothering has been observed more commonly among first time mothers according to people managing captive deer herds. Post-natal abandonment of calves has been described in severely stressed red deer hinds (5). Rejection of the neonate following dystocias could occur particularly if the calf was hypoxic and subsequently lacked vigour. Calves born below a certain 'critical' weight, (11 kg for elk), are described as unvialble and have a lower than 50 % chance of survival (6).

Nutritional status of the dam both pre-rut and during late gestation (studied in red deer C. elaphus) has a direct effect on the birthweight of the calf (6,7). The dam's nutritional levels in late gestation may affect colostral quantity as well. Transport, social stress or major physical stress in late gestation may result in agalactia, premature births or poor mothering. If extreme weather conditions prevail, (hot, or cold and wet), calves may die of hyperthermia or hypothermia respectively, if they do not have adequate natural or artificial shelter. If there is a design flaw in fencing neonates may end up on the opposite side of the fence from their dams. Separation may also occur if there are attempts to change grazing paddocks while some of the calves are still in hiding and separation leads to certain death.

According to this study many of the problems seen in neonates were associated with bottle raising. This may be expected for several reasons, number one, that they are being hand-reared in the first place. Such a situation would arise if animals are born too small and weak to suckle properly, if they are born too late in the season for good maternal lactation or if there is maternal rejection due to physiological, social,

environmental or physical problems. Any of these situations would result in colostral deprivation in an already diadvantaged neonate. The fact that elk are not domesticated causes insidious complications from the constant low grade stress to which captivity exposes them. This becomes a factor in the development of gastrointestinal tract ulcers which frequently compromise the well-being of hand raised young ungulates.

Viral or coliform enteritides occurred in calves and neonates which were being hand raised, which had low birthweights or were one of twins. Septicemias were also seen secondary to predisposing problems, similar to those described for calves with enteritis. There were 'outbreaks' and multiple deaths on some premises which suggested a serious environmental contamination problem. Meningitis was a common finding in septicemic elk calves. Neonates with pneumonia frequently had other problems as well. These included thymic atrophy, cryptosporidiosis and nonsuppurative encephalitis. Handfeeding of weak and downer calves was likely a factor in the cases with aspiration pneumonia. Unless great care were taken, people accustomed to feeding much larger neonates such as bovine calves, could overestimate the capacity of an elk calf. Mycotic pneumonia

could develop secondarily to bacterial or viral infection or immunosupression. Enclosed housing could readily create a problem in a species unused to being housed (8).

Neonates suffer trauma from misadventure, predatation or savaging by other mature animals, particularly if the enclosure conditions are crowded or otherwise stressful.

The calf group included animals from three weeks to about one year of age, although the majority were recently or not yet weaned. Of all the emaciated calves only two showed evidence of other problems. One had pneumonia, the other had a high number of fecal trichuris eggs and coccidial oocysts. Coccidia are not known to be pathogenic in elk under normal circumstances (9), but the presence of both these gut parasites are indicative of a contaminated feeding area. The most likely explanation of emaciation in calves would be inadequate lactation of the dam or insufficient good quality creep or post-weaning feed. Newly weaned calves are a very susceptible group going into a long cold winter with no reserves so they require good quality, easily accessible nutrition.

Clostridial enterotoxemia is usually associated with sudden change from a low to a high energy diet. It is a generally accepted recommendation that weanlings (and the other age groups), be vaccinated against clostridial diseases. Work carried out in New Zealand has demonstrated a temporary rise in detectable antibodies in vaccinated deer (10) but until now there has been no challenge trial to prove efficacy of vaccination.

Animals dying from from septicemia or a generalized infection fell primarily into two categories; hand-raised calves and those with omphalophlebitis or umbilical abscesses. The umbilical route of infection would suggest an environmental contamination problem. A. pyogenes and F. necrophorum, both ubiquitous organisms, would become a problem if wet weather, newly introduced animals or overcrowding increased the dose of exposure for vulnerable young stock.

P. multocida was a commonly isolated agent in pneumonic lungs of calves and mature elk. The subacute to chronic nature of bronchopneumonias could explain the emaciated state of many of the affected animals. It would be difficult in retrospect to determine which was the primary problem. That would be an

important distinction to be made by those responsible for management of the herds.

Tuberculosis is a rare occurence among wild cervids in North America (11). An outbreak of confirmed M. bovis was reported in North and South Dakota in the early 1980's. An epidemiological study suggested a zoological collection as the most likely origin of this outbreak (11).

Trauma as the number one cause of mortality in mature elk is largely a management problem. This is more true in a captive than in a semi-captive population for obvious reasons. Nevertheless, even in a refuge or national park where there is manipulation of such things as population density and distribution, the age structure of herds, movement of animals, winter feeding grounds etc., such problems could arise. In intensive, high density setups, management becomes the single most important factor in the prevention of trauma. Facility design, fencing, yards, runs and squeezes all become potentially dangerous areas for animals which are designed and programmed to escape man and other predators. A critical component in the handling of these animals in order to avoid accidents is calm,

quiet handling. If the elk are agitated or overheated, handling should be postponed.

The nature of reproductive behaviour in wild ungulates creates its own set of challenges. Removal of any hard antler before the onset of the rut is critical in a herd where there may be aggressive behaviour among males or by males towards females if they are in confined areas.

Another commonly seen avoidable source of trauma is in the transportation of elk. Penetrating wounds to feet and limbs are relatively common occurrences. These can progress to osteomyelitis or severe necrotizing cellulitis and eventually cause death.

Deaths due indirectly to trauma have been suspected in cases where clostridial organisms have been cultured from muscle or viscera on postmortem examination. Deep muscle bruising after a chase and even small vaginal tears acquired during the birth process have been the suspected cause of clostridial toxemias in unvaccinated animals.

By far the majority of emaciated elk had concurrent pathology. Malnutrition would predispose animals to other problems. Many elk being raised on enclosed parcels of land do

have nutritional problems either through ignorance or negligence of behalf of the people raising them. Subclinical losses from undernutrition have not been investigated yet but they are well recognized in other species. There is the misconception that because they do well on their own in the wild, elk do not require supplemental feeding if they are on pasture. The nutritional requirements of elk are variable throughout the year and do not resemble the requirements of most domestic animals due to their highly seasonal nature (12). Summer nutrition must be maximal in terms of quality and quantity, for both the lactational demands on the females (13) and the up coming breeding demands on the mature males. Rutting stags barely eat during the entire breeding season, experience tremendous weight loss, and enter the winter with little reserve. This reserve depends upon their condition by the end of the summer.

Bronchopneumonias and pulmonary abscessation cases most commonly yielded A. pyogenes and P. multocida. These lung infections have several possible origins. P. multocida, a resident of the oral cavity may become pathogenic given stressful conditions. Some of the cases seen did have footrot or soft tissue trauma with localized abscess formation which could

produce bacterial emboli. Necrotizing stomatitis which occasionally is associated with dental attrition, can readily produce multifocal lung lesions if bits of infected material are aspirated. In mycotic pneumonias there may be an environmental problem, either from mouldy feed or from crowded or poorly ventilated conditions which are not tolerated by species unused to a captive environment (8,14).

Almost all of the nephritis diagnoses were seen in females. Of the few cases in which bacteria were cultured, ubiquitous opportunistic organisms were found; E. coli, Pseudomonas and Enterobacter. The etiologies are likely to be similar to those in other domestic species.

A diagnosis of capture myopathy (CM) is difficult to prove. It is based largely on circumstantial evidence, history, typical post-mortem findings and a lack of any other explanation for death. The necropsy finding of 'shock gut' or 'hemorrhagic bowel syndrome' is sometimes the only abnormal finding. Occasionally, there is gross and histological evidence of muscle rupture and necrosis but this is not a routine finding. The majority of CM deaths descibed in this report were directly related to chemical immobilization, some were due to drug overdoses by people

unfamiliar with the species and procedures, some were due to post-immobilization complications and the animals took from several hours to longer than one week to succumb. There have been numerous unpublished reports of deaths from a combination of immobilization and hyperthermia. These have occurred in spite of chemical reversal of the immobilizing agent. It is always recommended that in hot weather any elective immobilizations be done only very early during the cool hours of the day, and never, if the temperature is greater than 25 C. Also, plans should be postponed if the animals are overheated or particulary agitated. Tranquilization interferes with thermoregulation. Hyperthermia and acidosis are key factors in the development of capture myopathy. Other situations leading to fatal CM include animals being tangled in fences (bad luck) and being carelessly transported (bad management).

Footrot cases were seen with equal frequency from all habitats, (farm, park and research herds), but there were none from Saskatchewan, North Dakota and South Dakota. These areas are semi-arid climatic zones. It is a possibility that wetter environments predispose hoof stock to foot lesions or create

conditions that allow more persistent environmental contamination (15).

Conclusion

This survey was intended to provide some basic data on veterinary problems encountered in elk raised in captive and semi-captive situations. There has been little work carried out yet to establish herd health and preventative medicine schemes which are based upon quanitative information regarding diseases of elk in this region. Practice up until now has been largely dependant upon experience with red deer (C. elaphus) and elk X red deer in New Zealand and Great Britain. Apart from reports such as this one, most useful information will come from good communications and cooperation between veterinary practitioners involved with game farmed animals and those involved in more research oriented roles at academic institutions. Open communications should result in more input and more published work that is available to a wider audience.

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TABLE I

Results of disease survey of elk (*Cervus elaphus canadensis*) in Western Canada and Northwestern United States

e Group	Fetus n=32		Neonate n=44		Calf n=23		Mature n=114	
jor Disease	n	%	n	%	n	%	n	%
rucellosis	8	25	-	-	-	-	-	-
ehydration	-	-	17	39	-	-	-	-
aciation	-	-	12	27	6	26	27	24
nteritis	-	-	11	25	6	26	-	-
eumonia	1	3	6	14	4	17	20	18
pticemia	1	3	10	23	4	17	-	-
rauma	-	-	5	11	4	17	30	26
en Diagnosis	19	59	6	14	1	4	7	6
econdary Disease								
pture myopathy							11	10
phritis							11	10
ootrot							10	9
ritonitis							9	8
rthritis							8	7
ocarditis							6	5

APPENDIX 2

Production Parameters in Deer Farming

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Introduction

Deer farming is becoming a popular new field in agriculture and provides an option for agricultural diversification for some farmers. It is an exciting new agricultural industry in which farmers can raise deer for both the venison and breeding stock markets.

Venison is becoming a popular meat among health conscious consumers. It has low fat content[9,10,21,22] and there is no routine use of either growth promotants or antibiotics in farmed deer. Venison can also be produced very efficiently because of the high natural fertility of deer observed in the wild[1,7] and in farmed situations[3,9,10,21].

Much of the research on red deer (Cervus elaphus) and fallow deer (Dama dama) has been carried out in New Zealand (Ruakura and

Invermay Research Stations and Massey University), Australia (University of Sydney Deer Research Unit), and Scotland (Rowett Research Institute, Aberdeen and Glensaugh Research Station, Laurencekirk). In Canada, research has been done at the Universities of Saskatchewan and Alberta on captive wapiti (Cervus elaphus canadensis). Because there are differences in reproductive biology between temperate and tropical deer species, this discussion and literature review has been limited to temperate deer species. Although much of this paper deals with production in red deer, it can readily be applied to a wapiti model.

As with any farming enterprise, the main aim is profitability whether it be in venison production, breeding stock or both. Success in both areas depends upon good management, a thorough knowledge of the biology of the species, and a good working knowledge of the handling of the animals. Many new producers will be unfamiliar with the handling and management of deer and will depend upon sound advice from those of us involved in deer farming research.

This paper is compiled from numerous studies carried out on various aspects of deer production. The topics covered by this report include growth and nutrition of various classes of stock, reproductive performance, venison production and associated management of several deer species.

Nutrition and Reproduction

It is difficult to decide upon a starting point relating to good livestock production because all the factors are so interdependant. Calf survival depends upon birthweight, which depends not only on maternal nutrition during late gestation, but upon maternal body weight at breeding[19,21] Maternal pre-rut weight is affected by nutrition during the previous lactation, and the weaning date of the previous calf. In the case of a first calver, her birth weight and date of birth would affect pre-rut weight, since late born calves rarely catch up with the herd weight average. Thus, interrelations continue. During the course of this paper, each component contributing to reproductive efficiency will be discussed as it relates to other parameters.

The following synopsis of a ten year study of the set up of a deer research farm, will give an idea of the range of problems encountered and corrected. Many of the performance records were based upon liveweights at various times throughout the year. The assessment of management techniques and projections for herd performance depended upon reaching target weights. These targets are determined for each age and sex class and change according to season and physiological status of the group.

The original study herd consisted of deer captured from the large feral population in New Zealand. Initially there were numerous difficulties to overcome because the deer were not adapted to captivity, and little was known about their management and handling. Over the course of the study valuable insight was gained into the management of deer under farmed conditions. The first problems became obvious during the calving season. Perinatal mortality was very high at 25% and 21% the first two years[16]. The high rates of perinatal mortality were largely associated with low birthweights due to inadequate nutrition of the hinds, poor mothering because of the pressure of recent captivity, and aggressive behaviour by the hinds towards calves other than their own. This aggression resulted in death from traumatic injuries to the neonates[16]. Antagonistic behaviour was probably exacerbated by stress from their recent capture and by unfamiliarity with the farm environment. Perinatal mortality decreased to 8% in each of the last five seasons. Mortality of calves from one week of age up to weaning decreased dramatically to less than 1%[18].

Weaning weights were greatly improved in the second five years of the study when compared to the first five years. The average weights had increased by 14% and 39% for female and male calves respectively[19]. During the early years, weight gain to weaning was lower than expected. This was a reflection of low birthweight, reduced hind milk yield due to poor nutrition and social and environmental stressors. Many changes were instituted

to ameliorate this situation. Improvements included mowing the pastures to promote lush vegetative growth, while providing artificial cover for the calves. Previous to this, pastures were allowed to grow long and stemmy to provide cover for the calves, but this created poor conditions for the lactating hinds[19]. The better management was effectively demonstrated by the 3 kg (6.4 to 9.5 kg) increase in average calf birthweights between the first two years and the last five years of the study[18]. Detailed studies demonstrated that mean growth rates of suckling red deer varied from 257 g/d on poor hill pasture, to 370 g/d on good improved pasture[13]. This additional gain emphasised the importance of pasture quality and quantity on calf weaning weight.

Weaning weight is a critical parameter for assessing management effectiveness and production potential in deer farming. It is the single factor that relates to future productivity and reflects back to herd management during gestation and lactation. Weaning weights were found to be reflected in 15 month liveweights. The 15 month liveweight in turn predicted the slaughter weight; it was correlated to future velvet antler weight in males; and it predicted puberty and breeding weight for females[17]. Because of these important relationships, a study was conducted to determine the factors most closely correlated to growth rate of calves between birth and weaning[16], since maximizing weaning weight was clearly desirable.

→ Tony elk change N2

Groups of red deer calves with their hinds were run on good quality ryegrass-clover pastures throughout the study. The calves were weighed at birth, at 6 to 8 weeks (midlactation) and at 12 to 13 weeks (weaning).

Analysis of various factors affecting liveweight led to the following observations:

- stag calves weighed 10% more than females at birth.
- a 1 kg increase in birthweight corresponded to an average 14 g/d increase in growth rate.
- males gained weight faster and were 13% heavier than females at 12 weeks.
- a 10 kg increase in dam liveweight at mating corresponded to a 0.33 to 0.5 kg increase in calf birthweight[19].

These trends were similar to findings in other species[7,8].

Once the weaning weights had been maximized, the next concern became the growth rate of calves from weaning to about 16 months of age (by the following autumn). In males it related to carcass size; in females, growth during this period influenced conception rates and future viable calf production[11]. It was necessary to determine the major factors affecting growth during this period.

Deer show a definite annual appetite cycle, with food intake decreasing during winter and increasing during the spring and summer[2,12]. The choice of diet and its effect on growth rate of

weaned calves during the winter was studied to determine its subsequent effect on growth at pasture[2]. The potential for compensatory growth during times of plentiful feed was tested by controlled restriction of winter diet. The trial was conducted on three groups of young deer (both sexes) which were fed one of three diets; low energy low protein (poor), high energy low protein (moderate), and high energy high protein (best) during the winter. All the deer were allowed free access to good pasture all summer.

The results indicated that all animals gained weight during the summer, but at variable rates. The deer on the poorest diet lost weight over winter but sustained a 30% higher compensatory liveweight gain compared to the other two groups during summer. The group on the moderate diet sustained the same rate of gain throughout the trial, while the group on the best diet showed a drop in summer liveweight gain from the highest late winter daily gain. These last two groups had similar growth rates during pasture feeding. Weight differences among the three groups were greatly reduced by the end of summer, but the deer fed the poorest winter diet still weighed less. (The hinds in this group also showed a reduced fawning rate the following year when compared to the other groups)[2]. By the end of the summer, the deer fed the best diet were only slightly heavier than those fed the moderate diet. Therefore, the moderate diet may be the most economical in that it still provides a sustained positive winter liveweight gain for young deer during winter.

In spite of reduced winter appetite, every effort must be made to encourage continued winter growth. This is particularly critical in long harsh winters such as those in most parts of Canada.

In this paper, it has been discussed that the growth of red deer calves is influenced by birthweight, sex, dam pre-rut weight, dam nutrition during lactation and winter nutrition. There are also several management decisions that affect calf growth between weaning and 16 months of age. One is the date of weaning, the options being pre- or post-rut (September or November in the northern hemisphere).

In a study of early (pre-rut) versus late (post-rut) weaning strategies, the calves weaned early had access to better pasture (based upon herbage mass and height of sward) than those left on their dams[15]. Liveweight gains of both groups of calves were similar between September and November. After being housed, the voluntary intake and growth rate of both early and late weaned calves declined and there was no difference in weight gain between groups. Interestingly, the late weaning treatment did have an effect on the hinds in that group. They showed a delay in rebreeding, resulting in an eight day delay in their mean calving date[19]. Based upon 350 to 400 g/d liveweight gain of calves[16,18] this would result in a 3 kg penalty on weaning weight the following

autumn of the next calf crop, which would in turn affect their potential productivity, etc.

The effects of winter planes of nutrition on reproductive parameters in North American wapiti have been examined. Hinds that maintained their body weight during the winter and spring produced the heaviest calves at birth, while those that lost more than 6.6% of body weight had the smallest calves[24]. Small calves under 11.5 kg (compared to a mean of 16.9 kg) had a lower than 50% chance of survival. Weight changes of wapiti hinds during the latter part of gestation were highly correlated to all three calf parameters measured; birthweight, average daily gain to four weeks and live weight at four weeks[24]. These results concur with those of studies of other cervids.

Stag Production Predictors

Red deer stag performance is judged mainly on three criteria: venison production, breeding success and velvet antler production. Studies have been designed to determine which liveweight, growth rate and antler measurements are useful and practical predictors for the three aforementioned parameters[17].

A New Zealand study found that an additional 1 kg of liveweight at three months of age (weaning) corresponded to an additional 0.9 kg of liveweight at 15 months[17], all other inputs

being equal. Therefore, weaning weight was felt to be a reasonable selection criterion for heavier 15 month venison stags. The 15 month liveweight was the best predictor of adult (two to five year old) weight. In the farming of red deer, stags are either slaughtered at one to two years of age for venison, or kept to older ages for production of velvet antler. Conventionally, selection for potential velvet production has been based upon velvet weight produced at two years of age. Because the major culling of stags for venison occurs as yearlings, an early predictor was sought. Based upon this work, the combination of 15 month liveweight and spike antler weight (first year's growth cut after the velvet has been rubbed off) was the best juvenile predictor of total velvet production[17], as well as adult live bodyweight.

The influence of winter feed restriction and summer compensation on skeletal development in red deer stags was studied[23] because nutritional effects on mineralized bone were felt to be potentially permanent markers of poor early nutrition. It was hypothesized that compromise of skeletal growth during the first winter may affect mature skeletal size and or strength, thus limiting the ultimate attainable body size. The metacarpus was used because of its rapid maturation, (which is possibly due to its weight bearing function). It was also convenient due to its accessability for radiography in live deer and ease of harvesting from butchered deer[23]. Metacarpal growth was measured

radiographically to detect any differences in diaphyseal length, breadth and cortical thickness. Results showed that winter feed restriction had no effect on metacarpal length. Winter feed restriction did cause a decrease in diaphyseal breadth, which was no longer detectable after a summer of unrestricted feeding. Restriction of winter feed did affect a permanent decrease in cortical bone thickness which would result in weaker bones less able to support a large body size[23].

Castration

There have been several studies of the effects of castration of deer from the point of view of both animal management and venison production. Early studies on fallow bucks demonstrated that castration at six months of age resulted in a decreased growth rate to 20 months, a lower mean carcass weight and a slightly lower dressing percentage[25]. There are, however, more factors to be considered. During the autumn breeding season, entire bucks undergo substantial weight loss varying from 10 to 30% of body weight depending upon their age[4,19]. This occurs as they become anorexic and extremely active and aggressive. During this period there are significant problems with confinement or handling of the animals. Hard antler must be removed to prevent severe damage to each other or to handlers. Even with only hard buttons left, there

is considerable risk of bruising and injury when bucks are confined together, for example, while in transit.

An Australian study compared carcass composition of castrated and intact fallow bucks. Muscles of castrates and intact bucks were individually dissected out and weighed to determine relative proportions of higher and lower quality cuts. The high quality muscles in the saddle and hind leg area were proportionately larger in the castrates, while the neck and thorax muscles were proportionately larger in the entire bucks[20].

Castration has advantages for both handling of bucks and marketing of venison. Advantages of castration include minimal handling and yarding problems, no administering of drugs, no yarding and handling time associated with spike antler removal, minimal fighting during transport or in paddocks and reduced risk of bruising resulting in carcass downgrading or condemnation.

Lactation and Production

It was mentioned earlier in this paper that prior to weaning, male red deer calves have a higher growth rate than females calves[16,18]. This greater weight gain of males places a greater lactational demand on hinds. In a nutrition study in Scotland, hinds on unimproved pasture were more likely to be barren the

following season if they had male calves[8]. In another study, calves from red deer hinds on improved pasture had much higher growth rates and weaning weights than those from hinds on unimproved native pasture. Calf growth rates were significantly positively correlated with milk yield throughout lactation[13]. In this experiment the high yielding well fed hinds returned to estrus significantly earlier (6.2 d $p<0.05$) than the poorly fed low yielding hinds[13].

This relationship between maternal nutrition and lactation, and its effect on fertility was further investigated[14]. Differences in milk yields of hinds on high or low planes of nutrition were associated with remarkably different patterns of suckling activity. Calves on improved pasture suckled less frequently but for longer periods of time than calves on poor pasture. Hinds on the poorer feed, supporting male calves with a higher suckling frequency returned to estrus 11 days later than those suckling female calves[8]. The principal influence of low planes of maternal nutrition was to increase suckling frequency by the calves in response to decreased availability of milk. This increased suckling stimulus produced higher levels of plasma prolactin, thereby extending the length of lactational anoestrus[14]. The subsequent delayed return to estrus would begin an endless cycle of potential problems; late calves, low weaning weights, late puberty, lower venison production...

Much of the research on various aspects of production in farmed deer has been carried out on species other than wapiti and fallow. The principles of production have been well established through work with other species. With consideration being given to local environmental and climatic conditions, the information presented in this document should be most useful for adjusted application by deer farmers in many different regions.

TARGET WEIGHTS FOR FALLOW DEER AND WAPITI (kgs)

		Birth	Weaning	Puberty (16 mo)	Adult (Sept)
Fallow Deer	♀	4.2	19	35 kg	42 - 50 kg
	♂	4.5	21	48 kg	75 - 100 kg
Wapiti	♀	17.5	100 kg	180 kg	235 - 260
	♂	19	110 kg	220	350 - 450

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APPENDIX 3

Reproductive Performance in Fallow Deer (*Dama dama*)

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This report is largely based upon fallow deer research carried out over the last six fawning seasons by Mulley and English at the University of Sydney Deer Research Unit. I was involved with their research program during the last fawning season. There are also numerous references to Asher's work in New Zealand dealing with fallow reproduction which supports many of the observations and conclusions in this paper.

Fallow deer are being raised in New Zealand for venison with secondary markets for velvet antler, hides, etc. Because the fallow deer industry is in the early stages of development, breeding stock is the most valuable product in Australia and North America. As with any animal production system, profitability in deer farming is primarily dependent upon high reproductive performance. The fertility of wild fallow deer is known to be very high, with conception rates of greater than 95%[1,8]. Data from Australia[12] and New Zealand[6] indicated that the best fallow deer farmers have been able to achieve weaning rates of 85 to 90%, but there was a wide variation among both farms and seasons.

Liveweight records are the most sound basis for assessing performance in livestock production. Deer are no exception. During the early stages of deer production it is important to regularly record weights of various classes of stock. This allows the farmer to correlate early weights and growth rates with

weights at later ages. These weight records have been used as indicators to predict production parameters including velvet production in males[20], onset of puberty[6,7,9], fawn birthweight, and fawn survivability[4,13,17].

Studies in Australia which have recorded the growth of fallow deer from birth to 12 months have shown the most rapid gain to occur between birth and weaning (mean of 92 days, S.D.=3)[13]. Female and male fawns gained 137 g/d and 153 g/d respectively, during this period. Between weaning and 12 months these growth rates decreased to 95 g/d and 125 g/d, respectively. Growth curves standards such as these must be independently established for each production region (for example, New Zealand compared to Canada) because climate and management system can vary considerably.

Pre-rut Weights and Fawn Birthweights

The growth period from weaning to puberty is very important since weight rather than age is the determinant for puberty. The critical pubertal weight for fallow does is 28 to 30 kgs[3,6]. Fawns born to farmed two year old fallow does (mean weight 36.7 kgs) were comparable in survivability to those born to adult does (mean weight 42 to 50 kgs) both in Australia and New Zealand[6,8]. This suggests the pre-rut weights of the rising two year olds were well above the critical level. However, the lower weights of young does corresponded to lower fawn birthweights. Up to parity six , doe

pre-rut weight increased, as did fawn birthweight[8]. Two year old does, usually the lightest in the breeding herd produced the lightest fawns. Fawn mortality was directly linked to birthweight[6,12], with less than 50% survival in fawns under 3 kgs. Therefore, the first fawn does usually produce the highest number of nonviable fawns (too small and weak to walk and suckle). Birthweight is normally about 10% of doe pre-rut weight. Two year olds and adult does should weigh approximately 37 kgs and 42 to 50 kgs respectively. Birthweight is, therefore, expected to be at least 4.0 kgs for all but fawns from the two year old does[6,8,15]. These results stress the importance of good nutrition to achieve maximum pre-rut weights in young fallow does.

Fawning and Weaning Rates

Fawning rate is the number of fawns born per 100 does exposed to the buck. This is largely a measure of the fertility of does and bucks. Weaning rate is the number of fawns weaned per 100 does bred. Of these two, the latter provides the most sensitive indicator of reproductive efficiency. Farming operations are dependant upon survival of progeny and weaning percentage takes into account both fertility of the breeding stock and farm conditions and management. Although these two indicators of reproductive performance do not distinguish between conception failure and prenatal losses, the arithmetic difference between them is a measure of survival after birth.

Post mortem diagnosis of dead fawns over several seasons gave a good indication of the post-natal reasons for reproductive wastage. Sixty-six percent of deaths were placed in the starvation-exposure category, which describes necropsy findings without giving a definitive cause[5,10,13]. The underweight nonviable fawn fails to survive because it is too weak to follow the mother, too weak to seek shelter, or too weak to stand and suckle. Exposure to hot sun leads quickly to dehydration and death. This may affect normal sized as well as underweight fawns in paddocks with inadequate shelter[12,13]. Wind or cold could also lead to death from exposure, and inadequate fencing could lead to fawn-dam separation and inevitable starvation. The next two main categories for neonatal fawn deaths were 16% from infectious agents and 9% from birth trauma. Less common causes included misadventure, predation, congenital problems and mismothering[4,13].

Weaning percentage can be adversely affected by environment and paddock conditions. Unfavorable weather conditions leading to drought can have a detrimental effect on pasture quality. Poor quality feed during late gestation has been associated with low birthweight and reduced viability of fawns[6,13,15]. Poor nutrition of does during lactation effects the growth rate and subsequent venison production for males, and lifetime reproductive potential of females[3,4].

Pregnancy Diagnosis

Early detection of pregnancy offers the advantage of obtaining premium prices for confirmed pregnant does. In addition, it allows transport of pregnant deer early in gestation thus minimizing risk to dam and fetus. It also useful for determining the stage at which reproductive failure occurs.

To help establish the timing of reproductive wastage, pregnancy diagnosis should be part of reproductive studies. One method is the blood progesterone assay which requires frequent sampling over three to four weeks[3]. This is impractical because of difficulties associated with frequent processing of the deer, and because handling stress can be detrimental to presumably pregnant deer. Per-rectal palpation is not possible on these small deer and abdominal ballotment or visual assessment is only reliable after 180 days[16].

A technique for pregnancy diagnosis by ultrasonography was found to be highly satisfactory[16]. It was rapid, easy and 100 percent reliable after 50 days gestation. Restraint of the deer was the time limiting factor. For small mobs, does were blindfolded and manually restrained on the holder's lap. For larger numbers of animals, it was more efficient to use a proper squeeze and drop floor chute. This procedure allowed access to

the hairless skin anterior to the udder. The ultrasound equipment consisted of a real time mechanical sector scanner with a 3.5 MHz transducer[16]. Cotyledons show up immediately as one cm sized structures in pregnancies of greater than 50 days duration, while fetal movement and anatomy was detectable after approximately 90 to 100 days.

Weaning Weights

Weaning weights and growth rates have been traditionally used as the basis for selection in meat production systems. In most species of livestock it has been almost universally found that more rapid growth at early ages is strongly correlated with larger adult size[11]. Since most deer farmers do not weigh newborn fawns, weaning weight is likely to be the basis for separating the future sires from venison bucks in males. Heavier weaning weight in females would allow them to reach pubertal weights earlier. This would lead to higher pre-rut weights. In turn, this would increase the probability of producing a fawn of viable weight the following season, since the pre-rut doe weight and fawn birth weight relationship has been well established[6,8,13].

Mean weaning weights of 95 day old fallow fawns were 19.7 kgs (females 19 kgs, males 20.5 kgs)[10]. This is not a useful guide to fawn growth unless the days between birth and weaning are known. Weaning ages in this study averaged 108 days and ranged from 93

days during a season of lush pasture growth to 127 days during a drought[10].

Weaning weight has been used as an index of herd performance by calculating the weight of weaned fawn produced per breeding doe in the herd. This animal production index measures the mass of fawn produced per doe per year. This can be easily calculated by farmers and allows comparison of reproductive performance from season to season. This index has been used in red deer production and accounts for numbers born, survival rate, and growth rate to weaning[7].

All does should be checked for fertility at weaning. A record should be kept indicating those that are lactating (wet) and those that have no udder development (dry). Lack of udder development indicates conception failure (which should be observed at pregnancy diagnosis) or loss of fawn at a later stage. This process is known as wet-drying the does.

Rearing Performance

Reproductive failure, or the number of breeding does in the herd minus the number of fawns weaned was estimated at 15 to 20% in a survey in New South Wales[15]. This was higher than expected

given the high fertility rates mentioned previously for fallow deer. These observations were the stimulus for a more thorough investigation of the causes of perinatal mortality.

While one study on 123 two year old does showed an 88% weaning rate[15] other studies showed a much lower weaning rate for young does[6]. These low weaning rates were related to the three major causes of perinatal mortality; non-viability due to small birth size (25%), starvation (19%) and dystocias (14%)[5]. Small fawns and dystocias were generally more frequent for first fawning does, while lack of mothering experience combined with harsh weather conditions such as extreme heat, could quickly lead to dehydration and starvation. It was also likely that the younger does were less successful at rearing than older, heavier does because of poorer lactation ability. On a commercial farm, weaning rates increased dramatically with higher pubertal weights. The does of 27 kg pubertal weight (16 months old, pre-rut weight) weaned 27% while the 35 kg pubertal weight does weaned 65%[5]. Even the higher rate is considerably lower than the 88% found by other researchers[15]. The high potential success rate suggests that good herd management can help realize reproductive potential. The importance of good growth rates and high prebreeding weights of young does is well in evidence.

There was a close examination of the relationship between parity and number of fawns successfully raised to weaning. By

their fifth fawning opportunity over half the does had experienced reproductive wastage at least once[15]. The ability to raise a first fawn may have implications for lifetime reproductive potential of fallow does. A number of does that failed to rear a fawn at their first attempt also failed at their second attempt[15]. Similar studies in sheep have shown rearing performance of two year old ewes to be a repeatable phenomenon[10]. There are many possible reasons for reproductive failure in does, including chronic infertility due to pyometra, cystic ovaries and neoplasia. Once again the importance of good herd recordkeeping is stressed. Good records allow farmers to select breeding stock on the basis of rearing performance and to cull non-productive does.

From various data that have been presented, the advancement of the breeding season would seem advantageous. If the rut were advanced, the fawning would occur one to two months earlier. In certain environments, this would permit closer coordination between maximum pasture growth and maximum lactational demands. In areas prone to drought or low summer rainfall, the pastures would offer the most lush vegetative growth in early summer. Fawns are entirely dependent upon good lactation early in life, before they begin consuming grass or other types of feed. Efforts to advance the fawning season have recently centered upon the use of melatonin, a pineal gland hormone which is naturally elevated only during times of darkness. As autumn approaches, levels of melatonin secretion increase. This stimulates breeding activity

in both males and females[5,13]. Subcutaneous melatonin implants have been used on fallow bucks and does throughout the summer, advancing the rut by four to eight weeks compared to untreated control animals[5,13]. As a result, the bucks, which are known to lose 15 to 30% of total bodyweight during the rut[5,12] have a longer period to regain condition before winter. This reduces the danger of winter death from lack of body fat reserves.

Methods of artificial control of breeding such as out of season breeding, artificial insemination (with semen collection, processing and storage) and even embryo transfer are at different stages of research. These areas show considerable promise.

The ideas and information presented here could be put to good use in fallow deer farm management. A manager who is attentive to the deer, familiar with their requirements and good with handling should be able to operate an efficient and profitable enterprise with these fertile, long-lived deer.

Table 2.1.19 Pre-rut weight (kg) and standard deviation (s.d.) for lactating does of different ages and the weight of their fawns where known

Age of does		Pre-rut weight of lactating does (kg)	Birth weight of their fawns (kg)	Fawn weight as proportion of doe pre-rut weight	Pre-rut weight of lactating does not matched with fawns
Rising 2	Mean	36.5 (20)	3.91	0.107	36.8 (67)
	s.d.	2.28	0.53		2.79
Rising 3	Mean	40.4 (26)	4.17	0.103	40.5 (51)
	s.d.	2.30	0.50		2.62
Rising 4	Mean	40.9 (19)	4.40	0.107	43.6 (77)
	s.d.	4.22	0.84		2.54
Rising 5	Mean	43.9 (11)	4.06	0.092	45.5 (27)
	s.d.	3.79	0.84		3.58
Rising 6	Mean	44.4 (2)	4.25	0.096	-
	s.d.	0.00	0.07		
Rising 7	Mean	48.6 (1)	4.70	0.097	-
	s.d.	-	-		
Unknown age	Mean	46.6 (66)	4.24	0.091	46.24 (405)
	s.d.	3.98	0.63		3.01
Total all ages	Mean	43.12 (145)	4.20	0.097	
	s.d.	5.10	0.65		

( ) = number of animals in sample

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APPENDIX 4

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YOHIMBINE HYDROCHLORIDE ADMINISTRATION TO REVERSE XYLAZINE SEDATION IN WHITE-TAILED DEER AND MULE DEER

Judit E. G. Smits, B.Sc., D.V.M., and Jerry C. Haigh, B.V.M.S., M.Sc.

Abstract: Three white-tailed deer (*Odocoileus virginianus*) and three mule deer (*O. hemionus*) were each immobilized three times with i.m. doses of xylazine hydrochloride at 1.3 mg/kg body weight. All six deer were given one of three dosage rates (0.5, 1.0, 1.5 mg/kg) of yohimbine hydrochloride administered i.m. during the three trials using a Latin Square experimental design. All deer received each dosage once 15–30 min after xylazine administration. The arousal time ranged from 2 to 10 min, and all deer were standing, regardless of which yohimbine dosage was used, within 4–15 min. The deer remained calm but alert during 1–2 hr of remote observation.

Key words: Yohimbine, immobilization reversal, xylazine, xylazine antagonist, white-tailed deer, *Odocoileus virginianus*, mule deer, *Odocoileus hemionus*.

INTRODUCTION

Xylazine hydrochloride (Rompun, Bayvet Division, Mississauga, Ontario L4W 2A1, Canada) is a commonly used sedative and immobilizing drug for handling captive cervids.[10] It causes sedation by the stimulation of presynaptic alpha 2 adrenergic receptors. which inhibits sympathetic outflow.[4] To avoid the risks associated with prolonged recumbency and sedation, a reversal agent is commonly used.[4,]

Yohimbine hydrochloride (Yohimbine HCl, Sigma Chemical Co., St. Louis, Missouri 63178, USA) is an indole alkaloid that antagonizes central alpha 2 adrenergic receptors. blocks neurotransmission, and reverses sedation by allowing sympathetic outflow.[4] Intravenous (i.v.) yohimbine has been shown to block xylazine-induced CNS depression and to act as an effective antidote to xylazine in cervids at a dosage of 0.125 mg/kg.[2,4,5,8,10] Intravenous yohimbine has been used successfully alone,[5] in combination with physostigmine (Antilirium, Forest Pharmaceuticals. Mississauga. Ontario L4W 2A1, Canada),[2] and with 4-aminopyridine (Sigma Chemical Co., St. Louis. Missouri 63178. USA).[8,10] After i.v. injections of yohimbine, sedated deer were observed to stand and walk within 2–14 min.[6,8,10]

The purpose of this study was to determine whether yohimbine administered i.m. can effectively reverse xylazine sedation in white-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*). The effective dose range of yohimbine was also determined.

MATERIALS AND METHODS

The animals used were three 8–9-mo-old female white-tailed deer. each weighing approximately 36 kg, and three mule deer, two females (one 9-mo-old, one adult) weighing 45 and 75 kg and one adult male weighing 75 kg. The deer were kept together in a wooded paddock and fed a diet of alfalfa-brome hay and herbivore pellets.

The yohimbine was formulated by the College of Pharmacy at the University of Saskatchewan (lot 102-01-1187) at a concentration of 8 mg/ml, pH of 5, and a tonicity of 35 mOsm. Because of hypotonicity of the formulation, it was diluted with equal parts of physiological sterile saline prior to administration to minimize complications from using a hypotonic solution.

The xylazine recovery time in both white-tailed deer and mule deer without reversal has been well established in the literature. Unantagonized deer sedated with xylazine

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Table 1. Analysis of the standing time (min) for xylazine hydrochloride-sedated white-tailed deer and mule deer after i.m. treatments with yohimbine hydrochloride at 0.5, 1.0, and 1.5 mg/kg.

Yohimbine (mg/kg)	*n*	Standing time (min), mean ± SD
0.5	6	9.83 ± 3.7
1.0	6	8.67 ± 3.9
1.5	6	7.17 ± 2.2

Table 2. Analysis of head-up time (min) for xylazine hydrochloride-sedated white-tailed deer and mule deer after i.m. treatments with yohimbine hydrochloride at 0.5, 1.0, and 1.5 mg/kg.

Yohimbine (mg/kg)	*n*	Head-up time (min), mean ± SD
0.5	6	5.67 ± 2.7
1.0	6	5.33 ± 3.4
1.5	6	6.00 ± 2.3

at dosages between 1.0 and 4.0 mg/kg have required 2–4.5 hr to standing time.[5,8,10] Because of the limited number of animals available for use in this study, the decision was made not to use untreated controls.

All deer were immobilized in the afternoon of the day of a trial with i.m. xylazine (100 mg/ml) at 1.3 mg/kg body weight administered by blowpipe. Immobilization occurred within 5–15 min. Immobilization was defined as the deer lying with its head on the ground and eyes closed, and no response to auditory or tactile stimuli.

The antagonist was administered 15–30 min after darting in the right gluteal muscle for trials 1 and 3 and in the left gluteal muscle for trial 2. Each animal received treatment A (0.5 mg/kg), B (1.0 mg/kg), or C (1.5 mg/kg) as determined by the randomized Latin Square design.[1,9] Appropriate yohimbine dosages were made up and labeled according to the animals receiving them. To control bias, the person assessing head-up time and standing time did not know which treatment had been used. The deer were observed from approximately 30 m to avoid inadvertent stimulation. The times between yohimbine injection, head-up time, and standing time were recorded. An analysis of variance (ANOVA) was performed using the Statistical Analysis System (SAS) (SAS Institute Inc., Cary, North Carolina 27511, USA) for a Latin Square design–fixed effects model. The ANOVA was done for two variables: 'head-up time' (first raising of head after antagonist administration) and 'standing time,' which was the end point.

RESULTS

All deer were immobilized within 5–15 min of xylazine administration. The end point or standing time and the head-up time for each of the three treatments are presented in Tables 1 and 2, respectively. Although Table 1 appears to indicate a decrease in the standing time for the higher doses of yohimbine, the ANOVA indicated no significant difference in response time among the three treatment levels used ($P < 0.01$). There were no significant differences in the time from antagonist injection to standing time attributable to either individual deer or the sequence of treatment (i.e., week of trial). There was a highly significant individual deer effect in the time between yohimbine administration and head-up time ($P < 0.01$).

DISCUSSION

Results of this preliminary study indicate that yohimbine administered i.m. is effective in reversing xylazine sedation in white-tailed deer and mule deer. In addition, yohimbine administered i.m. at 0.5 mg/kg body weight was as effective as at the two higher doses. The advantages of this latter finding are the lower cost per treatment, the smaller volumes of yohimbine required for xylazine reversal, and the reduced likelihood of myoclonia, pyrexia, and death[7] following accidental intracarotid injection of yohimbine.

The effect of yohimbine on head-up time in individual deer was highly significant.

This was primarily because one deer used in the study was very tame. This animal took the longest time to raise her head in every trial (all three treatments). The increase in head-up time in this deer may be a behavioral response in tame animals because her sedation also appeared to be more profound than in the other deer. In wild cervids or very excited animals, xylazine does not cause immobilization because of overriding sympathetic brain activity that partially prevents xylazine stimulation of the presynaptic alpha 2 adrenergic receptors.[3,10] Similarly, it is possible that xylazine in very tame animals may have a greater effect on these receptors resulting in deeper sedation.

In some situations, access to a vein in deer may be difficult. Based on the results in this study, i.m. yohimbine is effective in reversing xylazine sedation at a dosage of 0.5 mg/kg.

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